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An Examination of the Relative Age Effect in Developmental Girls' Hockey in Ontario

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An Examination of the Relative Age Effect in Developmental Girls' Hockey in Ontario

by

Kristy Smith

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An Examination of the Relative Age Effect in Developmental Girls'

Hockey in Ontario

By

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Declaration of Originality

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Abstract

The relative age effect (RAE) suggests that athletes born earlier in a sport's selection year are provided with greater opportunities for athletic success. While the effect has been well established in men's sports, little work has been directed at examining the RAE in women's sports. The purpose of the present study was to take an exploratory look at the RAE in developmental girls' hockey in Ontario. Relative age, community location and size, player position, age division, and level of play information were provided by the O.W.H.A. for 36,555 registrants. From the chi-square analyses, there was an over-representation in the first and second quartile and an under-representation in the fourth quartile across all age divisions and level of play. This suggests that the RAE is present in developmental girls' hockey, the magnitude of which varies with level of play, player position, and community size. It is expected that the increasing popularity of women's hockey will result in the RAE becoming even more pronounced.

Dedication

I dedicate my thesis to my baby boy Tristan

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Introduction

The factors involved in the development of elite athletes have become an area of interest in sport expertise research. A range of genetic and environmental factors have been identified. However, it is evident that the relationship between these factors and achieving athletic success is complex. Researchers have revealed that these factors can be divided into those having a direct influence on performance and those having an indirect influence (Baker & Logan, 2007). Direct effects are referred to as primary factors, and include obvious contributors such as genetic composition, training, and psychological aspects. Indirect effects are referred to as secondary factors and are frequently overlooked in athletic development. They include socio-cultural and contextual contributors. For example, lack of access to the highest levels of coaching and competition, or training in a suboptimal environment may disadvantage individuals with the most promising genetic makeup (Baker & Logan, 2007). The relationship of these contextual factors to the attainment of athletic success is only beginning to be understood (Baker & Horton, 2004; Baker & Logan, 2007; Baker, Schorer, Cobley, Schimmer, & Wattie, 2009a).

Relative Age Effects

One of these contextual factors has been termed the relative age effect (RAE). The RAE describes the potential advantages or disadvantages that result from differences in age among children in the same-age cohort (Barnsley, Thompson, & Barnsley, 1985; Barnsley, Thompson, & Legault, 1992). In many sport and education systems, children are grouped by chronological age (Baker, Schorer, & Cobley, 2010; Barnsley & Thompson, 1988). The intention of these age divisions is to provide developmentally appropriate training and competition, and an equal opportunity to achieve success

(Helsen, Starkes, & Van Winckel, 1998). However, there is increasing evidence that individual variability within these same-age cohorts is often resulting in participation and achievement inequalities among members (Baker et al., 2010). To illustrate, the Canadian youth hockey system uses a cutoff date of December 31st to group its players. Therefore, a child born in January will have up to a 12-month relative age advantage over a child born in December of the same year, leading to physical, psychological, and experiential differences in maturity among peers (Barnsley et al., 1992; Dixon, Horton, & Weir, in press). These differences can further lead to a variety of statistically significant selection advantages and playing opportunities for the older players, resulting in differences in the average attainment levels of otherwise similar individuals (Allen & Barnsley, 1993; Barnsley et al., 1992).

The RAE was first identified in the education system on standardized tests (Armstrong, 1966) and in the placement of students in streamed classes (Freyman, 1965; Jinks, 1964). It has subsequently been identified in a variety of sport and cultural contexts (for a review of findings, refer to Cobley, Baker, Wattie, & McKenna, 2009a; Musch & Grondin, 2001). Specific to hockey, the RAE emerged in the NHL in the 1970's (Wattie, Baker, Cobley, & Montelpare, 2007a), and was preceded by the effect in youth hockey (Barnsley & Thompson, 1988). The first examination of Canadian female ice hockey players did not reveal the presence of a RAE (Wattie et al., 2007a), but a larger, more comprehensive study of national level women's ice hockey showed a higher percentage of players being born in the first six months of the year (Weir, Smith, Paterson, & Horton, 2010). Additionally, a RAE emerged for skaters (forwards and defense) but not for goalies, suggesting that player position may impact the magnitude of the effect. This player position effect is in direct contrast to the earlier work of Grondin and Trudeau (1991) who reported an RAE only for male goalies, not for skaters.

Several mechanisms have been presented to explain these effects, including competition, physical development, psychological development, and experience (Musch & Grondin, 2001). However, it is likely that a combination of factors is involved and their exact contribution to the RAE is currently unknown (Musch & Grondin, 2001). The proposed ideas fit into two complementary hypotheses (Cobley, et al., 2009a). First, relatively older athletes tend to be physically larger and stronger than their younger cohorts (Malina, 1994), leading to greater athletic success in sports that involve physicality, such as football and hockey. This is especially true during adolescence (age 12-14 in girls, 13-15 in boys), when maturation variability is the greatest (Musch & Grondin, 2001). Secondly, relatively older athletes are more likely to be noticed by coaches because of their increased physical maturity and therefore, selected to more elite teams where they will experience higher levels of competition, training time, and coaching expertise (Helsen et al., 1998). Socio-cultural antecedents may also play a role. Musch & Grondin (2001) reviewed several research findings with respect to the RAE in sport and have suggested that population growth and an increase in the popularity of a sport may be important antecedents for the effect to emerge, as competition for a defined number of player positions is required.

The study of the RAE is important for the purpose of increasing awareness and understanding of the factors involved in this phenomenon. The process by which athletes are selected to varying levels of competition based on perceived talent leads to the RAE and actually reduces the talent pool, as younger players do not have the same opportunity to develop, and are more likely to have negative sport experiences, struggle with issues of competence and self-worth, and discontinue sport involvement altogether (Delorme, Boiché, & Raspaud, 2009; Helsen et al., 1998; Barnsley & Thompson, 1988). Further research in this area may provide a more accurate identification of the causes and factors involved in the RAE, or potential ways to reduce the detrimental effects associated with it (Cobley et al., 2009a).

Community Size

There is also evidence to suggest that not only does an individual's date of birth play a role, but also where they were born may contribute to the achievement of success in sport (Baker & Logan, 2007; MacDonald, Cheung, Côté, & Abernethy, 2009a). This influence, which has been termed the birthplace effect, has been found in both male and female athletics, although the magnitude of the effect varies between sports (MacDonald, King, Côté, & Abernethy, 2009b). Curtis & Birch (1987) were some of the first researchers to suggest the potential existence of a birthplace effect in a study of professional and Olympic hockey players in Canada and the U.S.A. They found that the largest cities (> 500,000) and rural communities (< 1,000) were underrepresented as birthplaces of elite hockey players. Similar results have been found among professional female soccer players and golfers (MacDonald et al., 2009b), U.S. baseball and elite hockey players (Côté et al., 2006), N.H.L. draftees (Baker & Logan, 2007), Olympic athletes (Baker et al., 2009a), Swiss tennis players (Carlson, 1988) and American football athletes (MacDonald et al., 2009a). Some possible mechanisms include the increased availability of social support in smaller cities, better access to facilities and space to practice, and more opportunity to experience the kind of play and practice associated with the development of expert performance (MacDonald et al., 2009a). The birthplace effect appears to be independent of the relative age effect (Baker & Logan, 2007; Côté, MacDonald, Baker, & Abernethy, 2006). However, the researchers suggest that it is likely they both play a role in the attainment of sporting expertise (Baker & Logan, 2007).

Research Questions & Hypotheses

The focus of the current study was on four main research questions. First, it sought to provide a further examination of the pattern of the RAE across different age groups in female developmental hockey leagues, in order to establish its existence at the developmental level. The term "developmental" is used in reference to an individual who is in the process of growth or progress in his/her athletic skill development at non-professional levels. This examination at the developmental level is important because only two percent of research has looked at female sport and has focused primarily on the adolescent age range (Cobley et al., 2009a). This study included a focus on several age groups, including pre-adolescent, adolescent, and post-adolescent cohorts. In addition, female ice hockey has dramatically increased in popularity in recent years and is quickly becoming more fully developed, as opposed to men's hockey which has been fully developed for many years. This may represent a unique and opportune time frame to study the RAE, as it has been suggested in previous literature that the existence of the RAE may be related to the depth of competition (Musch & Grondin, 2001) and the amount of opportunity available for participation (Musch & Grondin, 2001; Helsen et al., 1998). Similar studies have also provided support that the RAE is associated with broader social and cultural events, such as population expansion and sport participation increases (Cobley, Schorer, & Baker, 2008; Wattie et al., 2007a). However, it was hypothesized that the RAE will not emerge when looking at each age division as a whole, due to the inherent variability in the structure of the female hockey in Ontario.

Secondly, this study examined community size (also known as the "birthplace effect" in previous literature) as it relates to girls playing on developmental female teams. It is important to note that this study used the term "community size" as opposed to "birthplace effect," as it utilized the location of the individual's developmental team as opposed to her actual birthplace. This may represent a potential strength of this research study as it took into consideration the size of the player's current developmental context and reduced the possible effect of migration. Previous studies have questioned the validity of birthplace as an accurate proxy for an athlete's developmental environment, as there may be a discrepancy between an athlete's birthplace and subsequent location of youth sports involvement (Baker et al., 2009a; MacDonald et al., 2009a; Côté et al., 2006).

The issue of community size has received limited attention in sport expertise research as compared to the RAE alone (MacDonald et al. 2009; Côté et al., 2006). Researchers have found that cities with populations of between 1,000 – 500,000 people tend to produce a greater proportion of elite athletes (MacDonald et al., 2009) as opposed to very small or very large cities (as previously mentioned in Baker & Logan, 2007; Baker et al., 2009a; Carlson, 1988; Côté et al., 2006; Curtis & Birch, 1987; MacDonald et al., 2009). However, the RAE tends to be stronger in communities where there is more competition to be selected (Musch & Grondin, 2001), hinting that relatively older elite players may in fact come from the largest cities. Therefore, it was hypothesized that the RAE will emerge at a greater level in the larger Ontario cities versus smaller communities.

Thirdly, the study examined whether the patterning of the RAE changes between travel, where eligibility to play is restricted by skill level, and house league teams. It was expected that a stronger effect would be seen among the more elite, travel level teams where there is more competition for selection, as seen in male developmental hockey. Competition level, or level of play, has previously been identified as a critical factor in relative age research; this may be especially important when examining developmental hockey at youth levels (Wattie et al., 2007b). Barnsley & Thompson (1988) found greater RAEs among higher-level, travel teams at all age levels. The lower tiers of competition even exhibited a reversal of the effect, with a significant excess of relatively younger children. However, it is important to recognize the inherent differences that exist in the male and female organization of youth hockey. For example in the province of Ontario where data will be collected from, the Ontario Women's Hockey Association (O.W.H.A.) has an upper age limit in each division, but no lower age limit. Thus, a ten year old can choose to play with the seventeen year old players, as the emphasis is on participation. Therefore, a female youth hockey league will have considerable variability due to age. The Ontario Hockey Association (O.H.A.) in contrast, will have less variability because they structure players into two-year age ranges. Due to these differences in organizational structure, it was hypothesized that RAEs would only appear at the more elite levels where age groupings are likely to be more rigid. At the lower levels of developmental girls' hockey where more age variability will occur, it is expected that the effect will not be present.

Lastly, the study examined the impact of player position across the different developmental age divisions. Goalies were compared to skaters (forwards and defense) to determine if any significant differences in RAE patterning is present. Past research has produced conflicting results for position. It was hypothesized that a RAE will be found for skaters in this study.

Design & Methodology

Participant Sample

This study used a secondary dataset provided by the Ontario Women's Hockey Association. The dataset contained the birth dates, age and skill division, team locations, club name, home city, position (goalie versus skater), and O.W.H.A. player identification numbers for every female player (36,555 registrants) in the province of Ontario for the 2010-2011 season. Seven age divisions were examined to provide an evaluation of the entire developmental spectrum (refer to Table 1). All information was kept confidential. The study was approved by the University of Windsor Research Ethics Board.

Table 1 identifies several players who were not playing in the division that would be expected based on date of birth information. These players were kept in their reported divisions because the O.W.H.A. has allowed them to play there. Possible explanations for these outliers include: playing house league in a younger age division because of low skill level; or playing on a younger team because an age-appropriate team was not available in the community. These players account for a very small percentage (< 0.1%) of the total participant sample.

Data Analysis

The first step in data analysis was to examine the range of birth dates for accuracy within each player division. Any problematic birth dates that could not be verified or contained missing information were removed from the participant sample. Duplicates were also removed using player identification numbers at the individual's lowest level of play.

Table 1 – Age Demographics by Division

Division	% of Subjects Retained Post-Data Cleaning	Number of Subjects	% Proper Age Division	Age Range (Years)	Mean Age (In Years as of Dec31/2010)	Standard Deviation (Years as of Dec31/2010)
Novice (8 & Under)	96.08	3453	99.97	3-8 ++	7.63	0.96
Atom (10&Under)	97.13	4911	99.96	5-10 #	9.90	0.64
Peewee (12&Under)	96.88	6578	99.98	6-12 +	11.91	0.69
Bantam (14&Under)	96.29	6803	99.96	6-14 ^	13.88	0.64
Midget (17&Under)	98.06	6516	99.60	7-21 **	16.29	0.98
Intermediate (21&Under)	97.94	2570	99.96	11-21 *	17.79	2.01
Senior / Masters (Open Age)	94.08	5724	N/A	10-81	34.62	10.95

++ One player age 11
# One player age 11, one player age 12
+ One player age 22
^ One player age 16, two players age 15
** One player age 43
* One player age 60

All players were coded on the following variables: 1) birth quartiles (Q1 = January – March; Q2 = April – June; Q3 = July – September; Q4 = October – December) as per previous studies (Baker & Logan, 2007; Wattie et al., 2007a; Weir et al., 2010); 2) level of play (1 = 'A,' 'AA,' or 'AAA' players; 2 = 'B' or 'BB' players; 3 = 'C,' 'CC,' or recreational competitive players ; 4 = house league); 3) community size (1 = > 1,000,000 people; 2 = 500,000 – 999,999; 3 = 100,000 – 499,999; 4 = 30,000 – 99,999; 5 = 10,000 – 29,999; 6 = 5,000 – 9,999; 7 = 2,500 – 4,999; 8 = 1,000 – 2,499; 9 = < 1,000 as per previous studies (Côté et al., 2006; Curtis & Birch, 1987); and 4) player position (1=

goalies; 2 = skaters [forwards and defense]). For level of play, competition levels (example – 'A,' 'AA', and 'AAA') were combined due to the number of levels that are recognized by the O.W.H.A. In addition, few communities would have a team at each competition level defined by the O.W.H.A., but it is likely that the majority communities would have at least one team within each "level of play" outlined in this study. The important element in the level of play analysis will be the patterning between each tier of competition. Census counts for the year 2006 were used to identify community size as the 2011 statistics were not yet available. In addition, census subdivisions were maintained to ensure consistency.

A series of Chi-square analyses were performed using PASW Statistics 18 (IBM, SPSS), and all results were evaluated at $p < .05$.

a) A goodness-of-fit test was performed to test the expected distribution of birth dates (25% per quartile) versus the actual distribution for each quartile. For Canadian women's ice hockey, recent work by Weir et al. (2010) demonstrated equal distributions of birth dates across quartiles (25%) using population based data from Statistics Canada.
b) Nine separate goodness-of-fit analyses were performed for each individual community size within an age division, again based on an expected distribution of 25% per quartile. This allowed an examination of the relative age effect within each community size.
c) Two goodness-of-fit tests were performed to analyze the distribution of ages within each player position (goalies versus skaters).
d) Four goodness-of-fit tests were performed to examine the distribution of birth dates within each level of play.

e) A Chi-square test of independence was performed to examine the relationship between level of play and birth quartile. This allowed an examination of the patterning of the RAE across travel and house league players.

Statistically significant goodness-of-fit and test of independence chi-square values ($p < .05$) were then used to calculate the *w* effect size statistic, in order to determine the strength of the relationship. This statistic is calculated by taking the value of chi-square divided by the number of subjects [$w = \sqrt{(\chi 2 / n)}$]. Cohen (1992) proposed that *w* values of 0.1, 0.3, and 0.5 represent small, medium, and large effect sizes, respectively. Post-hoc tests were conducted for chi-square analyses producing *w* values ≥ 0.1. Standardized residuals were determined and a value of ≥ 1.96 indicated an over-representation, while a value of ≤ 1.96 indicated an under-representation in terms of relative age distribution.

Analysis of Results

Results

Birth quartile distribution for each age division is presented in Table 2. Significant chi-square values were found for all age divisions, with the exception of intermediate and senior / masters. A consistent pattern of over-representation in Quartile 2 and under-representation in Quartile 4 was present.

Tables 3 through 9 present the birth quartile distribution for each community size within each individual age division. Small communities of less than 2,500 people did not produce significant results in any age division. However, many medium-sized and large communities were found to have significant differences in birth date distributions in every age division (exception = senior / masters). Again, a pattern of over-representation in Quartile 2 and under-representation in Quartile 4 is once again evident.

Table 2 – Birth Quartile by Age Division

						Percent in Quartiles				Standardized Residuals			
Division	**Age**	**n**	χ^2	**df**	***w***	**Q1**	**Q2**	**Q3**	**Q4**	**SRQ1**	**SRQ2**	**SRQ3**	**SRQ4**
Novice	8 & under	3453	46.731	3	0.12	26.1	28.0	25.7	20.2	1.35	**3.50**	0.81	**-5.66**
Atom	10 & under	4911	71.443	3	0.12	27.3	27.3	25.3	20.0	**3.29**	**3.29**	0.47	**-7.04**
Peewee	12 & under	6578	115.435	3	0.13	26.7	28.5	25.2	19.6	**2.70**	**5.66**	0.36	**-8.72**
Bantam	14 & under	6803	117.617	3	0.13	25.5	29.2	25.4	20.0	0.83	**6.89**	0.59	**-8.31**
Midget	17 & under	6516	85.709	3	0.11	25.5	28.9	24.8	20.8	0.77	**6.27**	-0.27	**-6.76**
Intermediate	21 & under	2570	20.453	3	0.09	25.4	28.1	24.6	21.9	-	**-**	-	**-**
Senior / Masters	Open age	5724	15.800	3	0.05	25.4	26.7	24.9	23.0	-	**-**	-	**-**

Note: $\rho < 0.05$; df = degrees of freedom; NS = not significant

Table 3 – Birth Quartile by Community Size (Novice – 8 & Under)

					Percent in Quartiles				Standardized Residuals			
Community Size	**n**	χ^2	**df**	***w***	**Q1**	**Q2**	**Q3**	**Q4**	**SRQ1**	**SRQ2**	**SRQ3**	**SRQ4**
> 1 million	332	NS	3	-	23.2	30.4	23.5	22.9	-	-	-	-
500,000 – 999,999	446	7.937	3	0.13	27.1	28.5	24.7	19.7	0.90	1.47	-0.14	**-2.23**
100,000 – 499,999	1387	26.205	3	0.14	27.4	28.9	23.8	20.0	1.79	**2.86**	-0.90	**-3.74**
30,000 – 99,999	704	16.420	3	0.15	26.0	26.1	29.1	18.8	0.53	0.60	**2.19**	**-3.32**
10,000 – 29,999	377	NS	3	-	24.7	27.1	27.1	21.2	-	-	-	-
5,000 – 9,999	129	NS	3	-	26.4	28.0	25.6	20.2	-	-	-	-
2,500 – 4,999	26	NS	3	-	23.1	15.4	42.3	19.2	-	-	-	-
1,000 – 2,499	11	NS	3	-	27.3	9.1	45.5	18.2	-	-	-	-
< 1,000	41	NS	3	-	14.6	26.8	31.7	26.8	-	-	-	-

Note: $\rho < 0.05$; df = degrees of freedom; NS = not significant

Table 4 – Birth Quartile by Community Size (Atom – 10 & Under)

					Percent in Quartiles				Standardized Residuals			
Community Size	**n**	χ^2	**df**	***w***	**Q1**	**Q2**	**Q3**	**Q4**	**SRQ1**	**SRQ2**	**SRQ3**	**SRQ4**
> 1 million	424	11.396	3	0.16	22.2	28.8	29.2	19.8	-1.17	1.55	1.75	**-2.14**
500,000 – 999,999	630	7.727	3	0.11	27.9	26.2	25.4	20.5	-	-	-	-
100,000 – 499,999	1539	27.485	3	0.13	28.3	27.3	24.5	19.7	**2.62**	1.80	-0.24	**-4.17**
30,000 – 99,999	1109	14.134	3	0.11	27.7	27.4	24.2	20.7	1.79	1.61	-0.56	**-2.84**
10,000 – 29,999	758	18.422	3	0.16	26.0	29.2	26.3	18.6	0.54	**2.29**	0.69	**-3.52**
5,000 – 9,999	358	NS	3	-	29.1	26.3	22.9	21.2	-	-	-	-
2,500 – 4,999	42	NS	3	-	28.6	21.4	35.7	14.3	-	-	-	-
1,000 – 2,499	10	NS	3	-	40.0	20.0	20.0	20.0	-	-	-	-
< 1,000	41	NS	3	-	31.7	14.6	34.1	19.5	-	-	-	-

Note: $\rho < 0.05$; df = degrees of freedom; NS = not significant

Table 5 – Birth Quartile by Community Size (Peewee – 12 & Under)

					Percent in Quartiles				Standardized Residuals			
Community Size	**n**	χ^2	**df**	***w***	**Q1**	**Q2**	**Q3**	**Q4**	**SRQ1**	**SRQ2**	**SRQ3**	**SRQ4**
> 1 million	488	19.033	3	0.20	29.9	25.0	28.1	17.0	**2.17**	0	1.36	**-3.53**
500,000 – 999,999	853	17.542	3	0.14	25.9	30.0	24.0	20.0	0.53	**2.93**	-0.57	**-2.90**
100,000 – 499,999	1930	36.056	3	0.14	27.2	28.3	25.1	19.4	1.93	**2.89**	0.07	**-4.89**
30,000 – 99,999	1388	31.764	3	0.15	26.9	28.3	26.2	18.6	1.45	**2.47**	0.86	**-4.78**
10,000 – 29,999	1119	10.576	3	0.10	24.8	29.0	23.1	23.1	-0.17	**2.71**	-1.24	-1.30
5,000 – 9,999	592	13.905	3	0.15	26.2	28.7	26.5	18.6	0.58	1.81	0.74	**-3.12**
2,500 – 4,999	137	9.423	3	0.26	30.7	31.4	22.6	15.3	1.33	1.50	-0.56	**-2.27**
1,000 – 2,499	53	NS	3	-	18.9	32.1	30.2	18.9	-	-	-	-
< 1,000	18	NS	3	-	22.2	11.1	38.9	27.8	-	-	-	-

Note: $\rho < 0.05$; df = degrees of freedom; NS = not significant

Table 6 – Birth Quartile by Community Size (Bantam – 14 & Under)

					Percent in Quartiles				Standardized Residuals			
Community Size	**n**	χ^2	**df**	***w***	**Q1**	**Q2**	**Q3**	**Q4**	**SRQ1**	**SRQ2**	**SRQ3**	**SRQ4**
> 1 million	517	16.037	3	0.18	25.1	31.5	24.2	19.1	0.07	**2.97**	-0.38	**-2.66**
500,000 – 999,999	881	17.583	3	0.14	24.7	29.2	26.6	19.5	-0.15	**2.48**	0.93	**-3.25**
100,000 – 499,999	1908	30.067	3	0.13	24.7	29.5	25.3	20.6	-0.27	**3.89**	0.23	**-3.85**
30,000 – 99,999	1457	33.622	3	0.15	26.3	29.6	25.1	19.1	0.98	**3.50**	0.04	**-4.52**
10,000 – 29,999	1125	12.433	3	0.11	26.0	27.8	25.4	20.7	0.70	1.90	0.29	**-2.88**
5,000 – 9,999	678	11.097	3	0.13	26.8	28.2	25.2	19.8	0.96	1.65	0.12	**-2.73**
2,500 – 4,999	155	NS	3	-	25.2	31.6	21.9	21.3	-	-	-	-
1,000 – 2,499	43	NS	3	-	20.9	25.6	32.6	20.9	-	-	-	-
< 1,000	39	NS	3	-	25.6	20.5	35.9	17.9	-	-	-	-

Note: $\rho < 0.05$; df = degrees of freedom; NS = not significant

Table 7 – Birth Quartile by Community Size (Midget – 17 & Under)

					Percent in Quartiles				Standardized Residuals			
Community Size	**n**	χ^2	**df**	***w***	**Q1**	**Q2**	**Q3**	**Q4**	**SRQ1**	**SRQ2**	**SRQ3**	**SRQ4**
> 1 million	578	9.446	3	0.13	27.0	27.5	26.0	19.6	0.96	1.21	0.46	**-2.62**
500,000 – 999,999	911	13.351	3	0.12	25.7	29.6	22.8	21.8	0.42	**2.80**	-1.31	-1.91
100,000 – 499,999	1567	21.204	3	0.12	24.5	29.7	24.1	21.7	-0.34	**3.70**	-0.75	**-2.62**
30,000 – 99,999	1316	18.328	3	0.12	24.0	28.3	27.0	20.7	-0.72	**2.43**	1.43	**-3.14**
10,000 – 29,999	1215	15.548	3	0.11	25.8	28.7	24.7	20.8	0.53	**2.60**	-0.22	**-2.91**
5,000 – 9,999	713	18.215	3	0.16	28.8	28.1	24.5	18.7	**2.01**	1.63	-0.25	**-3.39**
2,500 – 4,999	159	NS	3	-	22.6	32.1	23.3	22.0	-	-	-	-
1,000 – 2,499	42	NS	3	-	26.2	26.2	28.8	19.0	-	-	-	-
< 1,000	15	NS	3	-	26.7	26.7	26.7	20.0	-	-	-	-

Note: $\rho < 0.05$; df = degrees of freedom; NS = not significant

Table 8 – Birth Quartile by Community Size (Intermediate – 21 & Under)

					Percent in Quartiles				Standardized Residuals			
Community Size	**n**	χ^2	**df**	***w***	**Q1**	**Q2**	**Q3**	**Q4**	**SRQ1**	**SRQ2**	**SRQ3**	**SRQ4**
> 1 million	103	NS	3	-	30.1	25.2	22.3	22.3	-	-	-	-
500,000 – 999,999	427	NS	3	-	25.3	26.0	26.2	22.5	-	-	-	-
100,000 – 499,999	1030	15.864	3	0.12	24.2	29.8	24.9	21.2	-0.53	**3.08**	-0.09	**-2.46**
30,000 – 99,999	542	7.889	3	0.12	25.5	29.5	23.8	21.2	0.21	**2.10**	-0.56	-1.76
10,000 – 29,999	279	NS	3	-	27.2	26.5	23.3	22.9	-	-	-	-
5,000 – 9,999	170	NS	3	-	27.1	24.1	24.1	24.7	-	-	-	-
2,500 – 4,999	19	NS	3	-	21.2	21.2	36.8	21.1	-	-	-	-
1,000 – 2,499	0	-	-	-	-	-	-	-	-	-	-	-
< 1,000	0	-	-	-	-	-	-	-	-	-	-	-

Note: $\rho < 0.05$; df = degrees of freedom; NS = not significant

Table 9 – Birth Quartile by Community Size (Senior / Masters – Open Age)

					Percent in Quartiles				Standardized Residuals			
Community Size	**n**	χ^2	**df**	***w***	**Q1**	**Q2**	**Q3**	**Q4**	**SRQ1**	**SRQ2**	**SRQ3**	**SRQ4**
> 1 million	769	NS	3	-	25.4	27.7	24.1	22.9	-	-	-	-
500,000 – 999,999	1627	11.031	3	0.08	24.2	28.1	25.2	22.5	-	-	-	-
100,000 – 499,999	1447	NS	3	-	26.6	25.3	24.9	23.2	-	-	-	-
30,000 – 99,999	964	NS	3	-	24.4	26.3	27.0	22.3	-	-	-	-
10,000 – 29,999	465	NS	3	-	27.5	24.3	24.9	23.2	-	-	-	-
5,000 – 9,999	420	NS	3	-	26.4	27.1	20.7	25.7	-	-	-	-
2,500 – 4,999	14	NS	3	-	21.4	35.7	14.3	28.6	-	-	-	-
1,000 – 2,499	18	NS	3	-	27.8	22.2	22.2	27.8	-	-	-	-
< 1,000	0	-	-	-	-	-	-	-	-	-	-	-

Note: $\rho < 0.05$; df = degrees of freedom; NS = not significant

Birth date distribution by position for each division is presented in Table 10 for goalies and Table 11 for skaters [forwards and defense]. For goalies there were only significant differences in the distribution of birth dates at the intermediate age level. Due to the small number of goalies in several age groupings, the sample was collapsed across all age divisions and the data were re-analyzed. The results revealed significant differences between quartiles among goalies with an over-representation in Quartile 2 and an under-representation in Quartile 4. For skaters there were significant differences for the novice, atom, peewee, bantam, and midget divisions. In each of these divisions, Quartile 2 was over-represented and Quartile 4 was under-represented.

The effect sizes were largest for the level of play analyses, ranging from small to medium. These results are presented in Tables 12 through 18. As evident in the tables, the magnitude of the effect size decreased with decreasing level of play across the age divisions. In addition, an over-representation of birth dates in Quartiles 1 and 2, and an under-representation in Quartile 4 was present.

Table 10 – Birth Quartile by Position (Goalies)

						Percent in Quartiles				Standardized Residuals			
Division	**Age**	**n**	χ^2	**df**	***w***	**Q1**	**Q2**	**Q3**	**Q4**	**SRQ1**	**SRQ2**	**SRQ3**	**SRQ4**
Novice	8 & under	20	NS	3	-	40.0	10.0	40.0	10.0	-	-	-	-
Atom	10 & under	71	NS	3	-	28.2	23.9	25.4	22.5	-	-	-	-
Peewee	12 & under	137	NS	3	-	29.2	25.5	22.6	22.6	-	-	-	-
Bantam	14 & under	165	NS	3	-	22.4	31.5	26.7	19.4	-	-	-	-
Midget	17 & under	200	NS	3	-	26.0	31.5	24.5	18.0	-	-	-	-
Intermediate	21 & under	67	11.030	3	0.41	25.4	40.3	22.4	11.9	0.07	**2.51**	-0.44	**-2.15**
Senior / Masters	Open age	179	NS	3	-	26.8	29.1	18.4	25.7	-	-	-	-
Total Sample	All ages	839	15.508	3	0.14	26.5	29.6	23.6	20.4	0.85	**2.64**	-0.81	**-2.68**

Note: $\rho < 0.05$; df = degrees of freedom; NS = not significant

Table 11 – Birth Quartile by Position (Skaters – Forwards & Defense)

						Percent in Quartiles				Standardized Residuals			
Division	**Age**	**n**	χ^2	**df**	***w***	**Q1**	**Q2**	**Q3**	**Q4**	**SRQ1**	**SRQ2**	**SRQ3**	**SRQ4**
Novice	8 & under	3433	46.158	3	0.12	26.1	28.1	25.6	20.2	1.26	**3.61**	0.71	**-5.57**
Atom	10 & under	4840	71.493	3	0.12	27.3	27.4	25.3	19.9	**3.25**	**3.33**	0.46	**-7.04**
Peewee	12 & under	6441	115.560	3	0.13	26.6	28.6	25.3	19.6	**2.59**	**5.70**	0.44	**-8.73**
Bantam	14 & under	6638	113.268	3	0.13	25.6	29.1	25.3	20.0	0.95	**6.71**	0.53	**-8.19**
Midget	17 & under	6316	79.558	3	0.11	25.5	28.8	24.8	20.9	0.73	**6.04**	-0.25	**-6.52**
Intermediate	21 & under	2503	16.346	3	0.08	25.4	27.8	24.7	22.1	-	-	-	-
Senior / Masters	Open age	5545	15.425	3	0.05	25.4	26.6	25.1	22.9	-	-	-	-

Note: ρ < 0.05; df = degrees of freedom; NS = not significant

Table 12 – Birth Quartile by Level of Play (Novice – 8 & Under)

					Percent in Quartiles				Standardized Residuals			
Level of Play	**n**	χ^2	**df**	***w***	**Q1**	**Q2**	**Q3**	**Q4**	**SRQ1**	**SRQ2**	**SRQ3**	**SRQ4**
Travel 1	156	17.692	3	0.34	30.8	35.3	19.9	14.1	1.44	**2.56**	-1.28	**-2.72**
Travel 2	266	16.647	3	0.25	32.3	26.3	26.3	15.0	**2.39**	0.43	0.43	**-3.25**
Travel 3	405	NS	3	-	29.6	24.0	24.7	21.7	-	-	-	-
House League	2626	31.337	3	0.11	24.7	28.3	26.1	20.8	-0.29	**3.41**	1.15	**-4.27**

Note: ρ < 0.05; df = degrees of freedom; NS = not significant

Table 13 – Birth Quartile by Level of Play (Atom – 10 & Under)

					Percent in Quartiles				Standardized Residuals			
Level of Play	**n**	**χ^2**	**df**	***w***	**Q1**	**Q2**	**Q3**	**Q4**	**SRQ1**	**SRQ2**	**SRQ3**	**SRQ4**
Travel 1	494	70.356	3	0.38	39.1	26.9	20.6	13.4	**6.25**	0.85	-1.93	**-5.17**
Travel 2	894	39.110	3	0.21	28.2	29.9	25.6	16.3	1.91	**2.91**	0.37	**-5.18**
Travel 3	669	13.015	3	0.14	26.8	27.5	26.8	19.0	0.91	1.31	0.91	**-3.12**
House League	2854	10.698	3	0.06	25.2	26.6	25.7	22.5	-	-	-	-

Note: $\rho < 0.05$; df = degrees of freedom; NS = not significant

Table 14 – Birth Quartile by Level of Play (Peewee – 12 & Under)

					Percent in Quartiles				Standardized Residuals			
Level of Play	**n**	**χ^2**	**df**	***w***	**Q1**	**Q2**	**Q3**	**Q4**	**SRQ1**	**SRQ2**	**SRQ3**	**SRQ4**
Travel 1	942	63.444	3	0.26	32.3	29.1	23.5	15.2	**4.46**	**2.51**	-0.94	**-6.03**
Travel 2	1269	36.365	3	0.17	27.8	29.4	24.4	18.4	**2.01**	**3.13**	-0.41	**-4.73**
Travel 3	865	20.045	3	0.15	26.2	29.2	25.7	18.8	0.73	**2.50**	0.39	**-3.62**
House League	3502	29.600	3	0.09	24.8	27.8	25.9	21.5	-	-	-	-

Note: $\rho < 0.05$; df = degrees of freedom; NS = not significant

Table 15 – Birth Quartile by Level of Play (Bantam – 14 & Under)

					Percent in Quartiles				Standardized Residuals			
Level of Play	**n**	**χ^2**	**df**	***w***	**Q1**	**Q2**	**Q3**	**Q4**	**SRQ1**	**SRQ2**	**SRQ3**	**SRQ4**
Travel 1	1368	84.743	3	0.25	31.8	30.0	21.6	16.5	**5.03**	**3.73**	**-2.49**	**-6.27**
Travel 2	1353	42.539	3	0.18	25.5	30.6	25.7	18.2	0.37	**4.12**	0.53	**-5.02**
Travel 3	850	17.868	3	0.14	24.8	30.6	24.1	20.5	-0.10	**3.26**	-0.51	**-2.64**
House League	3232	32.673	3	0.10	23.0	27.8	27.1	22.0	**-2.25**	**3.24**	**2.39**	**-3.38**

Note: $\rho < 0.05$; df = degrees of freedom; NS = not significant

Table 16 – Birth Quartile by Level of Play (Midget – 17 & Under)

					Percent in Quartiles				Standardized Residuals			
Level of Play	**n**	**χ^2**	**df**	***w***	**Q1**	**Q2**	**Q3**	**Q4**	**SRQ1**	**SRQ2**	**SRQ3**	**SRQ4**
Travel 1	1659	81.641	3	0.22	29.1	30.9	23.3	16.7	**3.35**	**4.78**	-1.36	**-6.77**
Travel 2	1485	21.432	3	0.12	25.1	29.5	24.3	21.1	0.09	**3.47**	-0.53	**-3.03**
Travel 3	941	15.927	3	0.13	24.0	29.6	25.7	20.6	-0.61	**2.86**	0.44	**-2.69**
House League	2431	NS	3	-	23.8	26.9	25.8	23.5	-	-	-	-

Note: ρ < 0.05; df = degrees of freedom; NS = not significant

Table 17 – Birth Quartile by Level of Play (Intermediate – 21 & Under)

					Percent in Quartiles				Standardized Residuals			
Level of Play	**n**	**χ^2**	**df**	***w***	**Q1**	**Q2**	**Q3**	**Q4**	**SRQ1**	**SRQ2**	**SRQ3**	**SRQ4**
Travel 1	696	38.080	3	0.23	29.7	31.2	22.4	16.7	**2.50**	**3.26**	-1.36	**-4.40**
Travel 2	132	NS	3	-	28.8	25.8	19.7	25.8	-	-	-	-
Travel 3	86	NS	3	-	31.4	20.9	22.1	25.6	-	-	-	-
House League	1656	8.831	3	0.07	22.9	27.4	26.1	23.6	-	-	-	-

Note: ρ < 0.05; df = degrees of freedom; NS = not significant

Table 18 – Birth Quartile by Level of Play (Senior / Masters – Open Age)

					Percent in Quartiles				Standardized Residuals			
Level of Play	**n**	**χ^2**	**df**	***w***	**Q1**	**Q2**	**Q3**	**Q4**	**SRQ1**	**SRQ2**	**SRQ3**	**SRQ4**
Travel 1	880	10.345	3	0.11	26.7	26.9	26.0	20.3	1.01	1.15	0.61	**-2.76**
Travel 2	1086	NS	3	-	27.1	26.6	23.3	23.0	-	-	-	-
Travel 3	580	NS	3	-	25.9	23.4	27.4	23.3	-	-	-	-
House League	3178	8.918	3	0.05	24.4	27.2	24.6	23.7	-	-	-	-

Note: ρ < 0.05; df = degrees of freedom; NS = not significant

The chi-square test of independence did find an association between level of play and birth quartile (tables 19-25) at the atom, bantam, and intermediate levels. For all age divisions there was an over-representation in Quartile 1 and an under-representation in Quartile 4 at the more elite Travel 1 level, which is similar to the pattern found in male developmental hockey. In contrast, the lower level house league teams show a reversal of this pattern with an under-representation in Quartile 1 and an over-representation in Quartile 4. Difference scores (observed count – expected count) are included in tables 19-25 for clarity purposes to reflect the patterning of the RAE within the entire sample.

Table 19 – Test of Independence Level of Play / Birth Quartile (Novice – 8 & Under)

					Difference Scores				Standardized Residuals			
Level of Play	**n**	χ^2	**df**	***w***	**Q1**	**Q2**	**Q3**	**Q4**	**SRQ1**	**SRQ2**	**SRQ3**	**SRQ4**
Travel 1	156	24.602	9	0.08	7.2	11.4	-9.1	-9.5	-	-	-	-
Travel 2	266				16.4	-4.4	1.7	-13.7	-	-	-	-
Travel 3	405				14.1	-16.3	-4.0	6.2	-	-	-	-
House League	2626				-37.7	9.4	11.4	16.9	-	-	-	-

Note: ρ < 0.05; df = degrees of freedom; NS = not significant

Table 20 – Test of Independence Level of Play / Birth Quartile (Atom – 10 & Under)

					Difference Scores				Standardized Residuals			
Level of Play	**n**	χ^2	**df**	***w***	**Q1**	**Q2**	**Q3**	**Q4**	**SRQ1**	**SRQ2**	**SRQ3**	**SRQ4**
Travel 1	494	63.859	9	0.11	57.9	-2.1	-23.1	-32.7	**5.0**	-0.2	**-2.1**	**-3.3**
Travel 2	894				7.5	22.5	2.5	-32.6	0.5	1.4	0.2	**-2.4**
Travel 3	669				-3.9	1.1	9.5	-6.6	-0.3	0.1	0.7	-0.6
House League	2854				-61.5	-21.5	11.1	71.9	**-2.2**	-0.8	0.4	**3.0**

Note: ρ < 0.05; df = degrees of freedom; NS = not significant

Table 21 – Test of Independence Level of Play / Birth Quartile (Peewee – 12 & Under)

					Difference Scores				Standardized Residuals			
Level of Play	**n**	χ^2	**df**	***w***	**Q1**	**Q2**	**Q3**	**Q4**	**SRQ1**	**SRQ2**	**SRQ3**	**SRQ4**
Travel 1	942	36.383	9	0.07	52.8	5.6	-16.6	-41.9	-	-	-	-
Travel 2	1269				14.6	11.5	-10.0	-16.1	-	-	-	-
Travel 3	865				-3.6	6.6	3.8	-6.8	-	-	-	-
House League	3502				-63.8	-23.7	22.8	64.7	-	-	-	-

Note: ρ < 0.05; df = degrees of freedom; NS = not significant

Table 22 – Test of Independence Level of Play / Birth Quartile (Bantam – 14 & Under)

					Difference Scores				Standardized Residuals			
Level of Play	**n**	χ^2	**df**	*w*	**Q1**	**Q2**	**Q3**	**Q4**	**SRQ1**	**SRQ2**	**SRQ3**	**SRQ4**
Travel 1	1368	62.293	9	0.10	86.1	11.8	-50.9	-47.1	**4.6**	0.6	**-2.7**	**-2.8**
Travel 2	1353				-0.1	19.2	4.9	-24.1	0	1.0	0.3	-1.5
Travel 3	850				-5.8	12.0	-10.5	4.3	-0.4	0.8	-0.7	0.3
House League	3232				-80.3	-43.0	56.5	66.8	**-2.8**	-1.4	**2.0**	**2.6**

Note: ρ < 0.05; df = degrees of freedom; NS = not significant

Table 23 – Test of Independence Level of Play / Birth Quartile (Midget – 17 & Under)

					Difference Scores				Standardized Residuals			
Level of Play	**n**	χ^2	**df**	*w*	**Q1**	**Q2**	**Q3**	**Q4**	**SRQ1**	**SRQ2**	**SRQ3**	**SRQ4**
Travel 1	1659	43.458	9	0.08	60.4	32.8	-24.9	-68.2	-	-	-	-
Travel 2	1485				-5.3	9.1	-7.7	4.0	-	-	-	-
Travel 3	941				-13.7	7.2	8.3	-1.8	-	-	-	-
House League	2431				-41.3	-49.1	24.4	66.1	-	-	-	-

Note: ρ < 0.05; df = degrees of freedom; NS = not significant

Table 24 – Test of Independence Level of Play / Birth Quartile (Intermediate – 21 & Under)

					Difference Scores				Standardized Residuals			
Level of Play	**n**	χ^2	**df**	*w*	**Q1**	**Q2**	**Q3**	**Q4**	**SRQ1**	**SRQ2**	**SRQ3**	**SRQ4**
Travel 1	696	31.916	9	0.11	30.4	21.2	-15.4	-36.2	**2.3**	1.5	-1.2	**-2.9**
Travel 2	132				4.5	-3.1	-6.5	5.1	0.8	-0.5	-1.1	1.0
Travel 3	86				5.2	-6.2	-2.2	3.2	1.1	-1.3	-0.5	0.7
House League	1656				-40.1	-11.9	24.1	27.9	**-2.0**	-0.5	1.2	1.5

Note: ρ < 0.05; df = degrees of freedom; NS = not significant

Table 25 – Test of Independence Level of Play / Birth Quartile (Senior / Masters – Open Age)

					Difference Scores				Standardized Residuals			
Level of Play	**n**	χ^2	**df**	***w***	**Q1**	**Q2**	**Q3**	**Q4**	**SRQ1**	**SRQ2**	**SRQ3**	**SRQ4**
Travel 1	880	NS	9	-	11.3	2.2	10.1	-23.6	-	-	-	-
Travel 2	1086				17.9	-0.7	-17.2	-0.1	-	-	-	-
Travel 3	580				2.6	-18.7	14.7	1.5	-	-	-	-
House League	3178				-31.8	17.2	-7.6	22.2	-	-	-	-

Note: $\rho < 0.05$; df = degrees of freedom; NS = not significant

Discussion

The over-arching purpose of this research project was to take an exploratory look at the RAE within developmental girls' hockey in Ontario. It was hypothesized that the effect would not be present when looking at the age divisions as a whole, due to the inherent variability in the structure of the O.W.H.A. This hypothesis was not supported for the novice, atom, peewee, bantam, and midget divisions. These divisions reached both statistical and practical significance, providing support that the RAE is now present in developmental girls' hockey. Each of these divisions showed an over-representation of players in Quartile 2; a pattern which has been previously been reported among adult female athletes (Baker et al., 2009b; Delorme et al., 2010; Weir et al., 2010). The odds ratios of several other studies involving female youth reveal that this pattern may also be present in other sports. Players were twice as likely to be born in Q2 versus Q4 in volleyball (age 12-13 years, 14-15 years; Grondin, Deschaies, & Nault, 1984b), in swimmers (age 11-18 years; Baxter-Jones, 1995), in soccer (age 17-18 years; Helsen et al., 2005), and three times as likely in basketball (age 15-16 years; Hoare, 2000) A potential explanation for this finding is that the relatively older, more experienced and physically developed Q1 athletes may be playing a more popular sport, or perhaps playing in the male developmental system. However, this theory is only speculation and requires further investigation.

This is the first study to show this RAE pattern among younger, female age groups. However, this is a reasonable finding to expect being that the greatest differences in physical maturation exist pre-puberty. Malina (1994) reported that statures of hockey players tend to be most variable during childhood and early adolescence, especially for those born in Canada. The magnitude of the effect size remained relatively constant from the youngest age division until adulthood (~age 18), after which it did not reach significance. However, the calculation of standardized residuals revealed that the over-representation in Q1 and Q2 increased with age. This finding provides support for the previously discussed two-part complementary hypotheses (Cobley, et al., 2009a), where the increased level of physical maturation of relatively older players initially contributes to relative age inequalities, and later selection advantages perpetuate these advantages for older cohorts. For hockey players, it may lead to future scholarships or opportunities to participate on elite level teams. These findings linked with the earlier findings of Weir et al. (2010) suggest that the magnitude of the RAE in Canadian women's ice hockey may become even stronger in the future given its presence in the youngest age groups of the developmental hockey system. This builds upon Murray's (2003) idea of an 'accumulated advantage,' where the presence of early advantages continue and increase with time, which may be reflected in the quality of elite women's ice hockey at the National level in the years to come.

Differences in physical maturation alone cannot explain the RAE. Previous studies involving adolescent (Schorer, Cobley, Büsch, Bräutigam, & Baker, 2009) and adult cohorts (Weir et al., 2010) have found no significant differences in the height and weight of hockey participants, suggesting that pre-existing differences level out in later years. A comparison of physical variables was not possible in this study because the O.W.H.A. does not record any anthropometric data. However, differences in physical maturation of pre-adolescent females would be an interesting variable to investigate in the future.

This study also examined community size as it relates to girls playing on developmental female teams. Depth of competition has been proposed as a prerequisite for the RAE to emerge (Musch & Grondin, 2001) and the amount of opportunity available for participation (Musch & Grondin, 2001; Helsen et al., 1998). Therefore, it was hypothesized that larger communities would exhibit relative age differences, and small communities would not. This hypothesis was supported. While the results did vary between age divisions, smaller communities did not show a RAE, while larger communities did. These larger communities would arguably have greater opportunities for sport participation, and also a greater number of individuals seeking to fill those spots, providing the pre-requisite feature of competition for membership on teams. Previous research has found the two variables to be independent of one another (Baker & Logan, 2007; Côté et al., 2006). However, this examination of community size is unique in that it looks at the athletes in their current developmental context, as opposed to the birthplaces of professional athletes. Therefore, comparisons with previous research are difficult.

Significant results were found for skating positions (forwards and defense) at the novice, atom, peewee, bantam, and midget levels; initially, only the intermediate division was found to be significant for goalies. However, when the sample was collapsed across age divisions, a significant chi-square value was found. While past research has produced conflicting results for player position in men's hockey (Grondin & Trudeau, 1991), the findings for skaters are consistent with those reported by Weir et al. (2010) for women ice hockey players. While significant differences among goalies were not reported in that study, this may have been a result of the small sample size in that study. Hockey is a sport where a greater level of aerobic endurance and increased physical prowess is advantageous for both forwards and defensive players. Geithner, Lee, and Bracko (2006) suggested that skating positions require an increased level of physical demands, and consequently, a RAE emerges among these players. In contrast, the current study suggests that a RAE is present for all positions in female ice hockey, a finding supported by Addona & Yates (2010) among N.H.L. hockey players.

The examination of level of play produced the most interesting findings. The magnitude of the RAE increased with increasing level of play. This effect has been previously found in male hockey (Barnsley & Thompson, 1988), but this is the first time it has been reported at the female developmental level. The pattern was relatively consistent for every age division, with the exception of the intermediate and senior / masters which revealed significance only at the most elite levels of play. These results support the hypothesis that the effect is greater at more elite levels where there is more competition for selection. As previously discussed, competition level has been identified as a critical factor in relative age research (Wattie et al., 2007b). A meta-analysis by Cobley et al. (2009) reported that RAE risk increased with skill level where greater levels of competition would be present, with the highest risk evident at the pre-elite stage.

The test of independence revealed a significant relationship between birth quartile and level of play in this sample of hockey players. The pattern that emerged of an over-representation in Quartile 1 and an under-representation in Quartile 4 at the more elite travel levels, and a reversal of this pattern with an under-representation in Quartile 1 and an over-representation in Quartile 4 on house league teams is congruent with what would be expected. In addition, the results revealed that not only are fewer Q4-born players competing at the more elite levels of play, but there are fewer Q4-born players enrolled in the developmental hockey system in general. Barnsley and Thompson (1988) reported similar patterns among Q4-male developmental hockey players. This trend was observed in the O.W.H.A. at every level of play including house league, and in every age division up to approximately 18 years of age. The registration numbers leveled out between quartiles in adulthood. This may suggest that parents are reluctant to even register their smaller, later-born children in a physical sport such as a hockey. However, this requires further investigation beyond the scope of this study.

Strengths & Limitations

This study makes several unique contributions to the existing body of research. First, it examines the RAE in female hockey from a developmental perspective. Studies focused on female athletes have been lacking, especially in the area of youth sport. This study incorporated pre-adolescent, adolescent, and post-adolescent age groups, which allowed for the full range of physical maturation to be examined. Secondly, this study maintained the inherent structure of the O.W.H.A. by including all eligible players at each age division. This is important due to the value placed on participation by this organization. However, this structure makes comparison to other literature difficult because male developmental hockey is often organized into two-year age groupings. An additional limitation to using these age ranges is that it is not possible to determine the reasons why a player might be playing in a particular age division. For example, parents might choose to enroll their child at a higher level for development purposes, or an age-appropriate team might not be available in smaller communities. These kinds of questions cannot be answered with a secondary dataset, and further research will be necessary before conclusions of that nature could be made. Thirdly, this study attempted to link community size to the RAE at the developmental level. As previously discussed, other studies have found the birthplace effect and the RAE to be independent of one another (Baker & Logan, 2007; Côté et al., 2006). However, these studies examined these effects in the context of one's likelihood of becoming a professional athlete. The current study suggests that a greater likelihood of a RAE is related to the size of the community in which the developmental team is located.

As previously mentioned, this study used the term "community size" as opposed to "birthplace effect," as it best represented the location of the individual's developmental team as opposed to her actual birthplace. This may represent a potential strength of this research study as it took into consideration the size of the player's current developmental context and reduced the possible effect of migration. It is reasonable to suggest that players from small communities in particular, might choose to register for teams in larger communities for competition purposes, or perhaps due to the absence of a team in their own community; these possibilities should be accounted for. Previous studies have questioned the validity of birthplace as an accurate proxy for an athlete's developmental environment, as there may be a discrepancy between an athlete's birthplace and subsequent location of youth sports involvement (Baker et al., 2009a; MacDonald et al., 2009; Côté et al., 2006). The findings are still limited by the potential influence of migration; however, these effects have been assumed to be negligible in previous research, due to equal and opposite net migration (Côté et al., 2006).

Future Directions

The study of the RAE in developmental girls' ice hockey would benefit from the use of both quantitative and qualitative investigation methods. Specifically, interviews with players, parents, coaches, and sport administrators could be used to gain a greater understanding of the RAE in this area of sport. The chi-square analyses typically used in RAE research and in this study, determine whether significant differences exist. However, it is not possible to answer the question 'why?' with these methods. For instance, we know that the youngest children in a same-age cohort are not participating at the same rate as those who are relatively older, but we do not know the specific reasons contributing to this trend. Using the O.W.H.A.'s player identification number, it may be possible to track where and at what age the greatest rate of dropout from hockey is occurring. For example, it is possible that level of play and size of the community where the team is located, or entrance into adolescence, may play important roles in an athlete's choice to continue participation.

Future studies should seek to identify the underlying reasons why the 2nd quartile is often over-represented in female sport versus male sport. Are the older, more experienced and physically developed Q1 athletes playing a more popular sport, or perhaps playing in the male developmental system? Parents may be choosing to register their daughters in male hockey, believing that this will provide a greater likelihood of future success or perhaps in sports that traditionally have greater female participation. Interviews could be used to determine why an athlete might choose one sport organization over another.

Further research should also seek to develop realistic intervention strategies to eliminate athlete selection biases, perhaps by identifying the specific metric that coaches use when selecting players to teams. For example, are they using physical size or motor skill performance to identify the most talented players? It is possible that simply delaying the processes of selection to elite teams until after the stages of puberty and maturation are complete (for example, beyond 15-16 years of age) might reduce the magnitude of the RAE. Selection processes facilitate earlier athlete scrutiny, assessment, and identification, which increase the likelihood and magnitude of relative age inequalities. Delaying selection may reduce relative age disadvantages, and also indirectly help reduce the risk of compromising the health and motivation of young athletes (Cobley et al., 2009; Baker et al., 2010).

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Appendices

Appendix A

Review of Literature

The factors involved in the development of elite athletes have become a primary focus of sport expertise research. Previous ecological development theories have explained human behaviour as the result of synergistic interactions between internal, individual characteristics and external, environmental influences (Baker, Schorer, Cobley, Schimmer, & Wattie, 2009a; for an example, refer to Bronfenbrenner's Ecological Systems Theory, 1977). Likewise, models of sport development have identified a range of individual and environmental factors that may interact together to influence success (Baker et al., 2009a; Baker & Horton, 2004). However, it is evident that the relationship between these factors and achieving athletic success is complex.

Researchers have revealed that these factors can be divided into those having a direct influence on performance and those having an indirect influence (Baker & Logan, 2007). Direct effects are referred to as primary factors, and include obvious contributors such as genetic composition, training, and psychological aspects. Indirect effects are referred to as secondary factors and are frequently overlooked in athletic development. They include socio-cultural and contextual contributors. For example, lack of access to the highest levels of coaching and competition, or training in a suboptimal environment may disadvantage individuals with the most promising genetic makeup (Baker & Horton, 2004; Baker & Logan, 2007; Baker et al., 2009a)

The relationship of these contextual factors to the attainment of athletic success is only beginning to be understood. For many years, it has been accepted that an athlete's month of birth may contribute to his or her likelihood of reaching elite status in sport.

Recent research has also provided support for the theory that the size of an athlete's birthplace plays a role in athletic achievement (Baker & Logan, 2007). This document and the proposed study will examine these two contributors to individual athlete development.

Relative Age Effect

The first of these two contextual factors has been termed the relative age effect (RAE). The RAE describes the potential advantages or disadvantages that result from differences in age among children in the same-age cohort (Barnsley, Thompson, & Legault, 1992; Barnsley, Thompson, & Barnsley, 1985). In many sport and education systems, children are grouped by chronological age (Baker et al., 2010; Barnsley & Thompson, 1988). The intention of these age divisions is clearly positive. It is done for the purpose of providing developmentally appropriate training and competition, shared social experiences, fair play, and an equal opportunity to achieve success (Helsen, Starkes, & Van Winckel, 1998). However, there is increasing evidence that individual variability within these same-age cohorts is often resulting in participation and achievement inequalities among members (Baker, Schorer, & Cobley, 2010). In fact, the older one is relative to peers, the greater their likelihood of eventually becoming an elite athlete (Musch & Grondin, 2001).

To illustrate, the Canadian youth hockey system uses a cutoff date of December 31^{st} to group its players. Therefore, a child born in January will possess up to a 12-month relative age advantage over a child born in December of the same year. While this may not seem like a large difference, it could lead to physical, psychological, and experiential differences in maturity among peers (Barnsley et al., 1992; Dixon, Horton, & Weir, in press). These differences may be further exacerbated between a fast maturer born in

January and a late maturer born in December (refer to Appendix B for an illustration; Musch & Grondin, 2001). Consequently, these developmental differences can further lead to a variety of statistically significant selection advantages and playing opportunities for the older players, resulting in meaningful differences in the average attainment levels of otherwise similar individuals with the same physical age (Allen & Barnsley, 1993; Barnsley et al., 1992).

Structure of the Developmental Youth Hockey System

For the purposes of this study, it is important to understand the developmental structure of youth hockey in North America. The majority of Canadian communities, and many American communities, have organized age-based hockey leagues. There are leagues for within-community (often identified as "house-league hockey") and between-community competition (often identified as "travel hockey"), the latter usually involving the more elite players who are selected for their greater skills and talent. Smaller regions may have only one or two travelling teams for each age division, while larger cities likely have several. Many communities also have high school teams. However, these are not a significant training base for the more elite players due to lower levels of competition, shorter playing seasons, and fewer practice sessions compared with travel teams. In addition, players are often scouted by elite level teams before they even reach high school age (Curtis & Birch, 1987).

The players on travel teams are first scouted by minor professional Junior A, B, and C-level teams, and later by scouts from major professional teams, and college / university teams. The scouts from Junior teams monitor 13- to 15-year-old players, just before they are eligible to play Junior hockey (ages 15 to 20 years). It is from these Junior teams (specifically Junior A), that most professional players are drafted.

University players are also scouted by professional teams. However, most professional players are signed by teams by the age of 19, and therefore universities are not a major source of player recruitment (Curtis & Birch, 1987). It is important to note that this description of the structural organization of youth developmental hockey applies to male players; yet female hockey is developing at a rapid rate and is starting to resemble the male system. However, there are still inherent differences between the two systems that must be considered in this study. For example in the province of Ontario, where data will be collected from, the Ontario Women's Hockey Association (O.W.H.A.) has an upper age limit in each division, but no lower age limit. If a ten year old chooses to play with the seventeen year old players, she may do so. The emphasis is on participation. Therefore, a female youth hockey league will have considerable variability due to age. The Ontario Hockey Association (O.H.A.) in contrast, will have less variability because they structure players into two-year age ranges.

From the structure of this developmental sport system, hockey can be generalized into a model characterized by these components: 1) a number of discrete stages of training; 2) entry to the first stage during childhood (when it may prove to be very difficult to observe ability and maturity as separate entities); 3) differential training is provided during each stage to different streams; and 4) selection to streams on the basis of observed skill (Allen & Barnsley, pp. 653, 1993). Young athletes are characterized by ability (which is innate), maturity (which increases with age), and skill (which is developed through accumulated levels of training and practice). Only skill can be observed directly; ability cannot. Skill is an increasing function of ability, maturity, and accumulated training. Maturity is normally distributed among individuals of the same calendar age, with a variance that declines to zero as an age group reaches adulthood.

Therefore, differences in skill among adults will reflect either differences in ability or differences in accumulated training (Allen & Barnsley, 1993).

History of the RAE - Education

The RAE was first identified in the education system on standardized tests (Armstrong, 1966) and in the placement of students in streamed classes (Freyman, 1965; Jinks, 1964). Subsequent research has consistently identified variations in developmental outcomes among same-age cohorts (Baker et al., 2010). For example, relatively older students tend to have higher achievement scores across a variety of subjects and different countries (Bedard & Dhuey, 2006; Smith, 2009), are more likely to be placed in special education programs for gifted children (Cobley, Baker, Wattie, & McKenna, 2009b), and are more likely to be high school student leaders (Dhuey & Lipscomb, 2008). In contrast, relatively younger students have lower attendance rates (Cobley et al., 2009b), are more likely to be retained for an additional year in the same grade (Elder & Lubotsky, 2009), are more likely to be diagnosed with a learning disability (Martin, Foels, Clanton, & Moon, 2004; Elder & Lubotsky, 2009), and are less likely to pursue a post-secondary education (Bedard & Dhuey, 2006). It is evident from the existing body of research that both potential short-term and long-term (dis)advantages exist in education as a result of the RAE (Thompson, Barnsley, & Dyck, pp. 83, 1999). The RAE is also applicable within the sporting context, although differences do exist. These differences may be due to the compulsory nature of school attendance versus voluntary participation in sport. However, important parallels between the two contexts do exist (Musch & Grondin, 2001).

History of the RAE – Sport

The RAE is a less-understood and less-recognized phenomenon in sport (Musch & Grondin, 2001). Grondin, Deschaies, & Nault (1984a) and Barnsley et al. (1985) were some of the first researchers to propose a possible relationship between the RAE seen in education and a similar effect in the sporting context; this effect results in relatively older athletes having a competitive advantage over their relatively younger cohorts. Grondin et al. (1984a) found unequal distributions of birth dates for male Canadian ice-hockey players, and both male and female volleyball athletes at the recreational, competitive, and senior professional levels. Likewise, Barnsley et al. (1985) identified a very strong linear relationship between month of birth (from January to December), and the proportion of hockey players playing in the National Hockey League (N.H.L.), the Western Hockey League (W.H.L.), and the Ontario Hockey League (O.H.L.). As previously stated, hockey is a sport that organizes players by age according to the calendar year; therefore, a cutoff of December 31st is used. Researchers have proposed that individuals with birth dates earlier in the year (beginning January 1st) are provided with significant advantages to achieve success in the sport (Musch & Grondin, 2001). The history of the N.H.L. was examined by Wattie, Baker, Cobley, & Montelpare (2007a), and it was demonstrated that the RAE emerged in professional male ice-hockey players during the late 1970s. This conclusion was made based on significant differences between quartiles (Quartile 1 = January-March; Quartile 2 = April-June; Quartile 3 = July-September; Quartile 4 = October-December) for players born after 1956 (X^2 ranging from 8.31 to 28.02, all $p < 0.05$). Barnsley & Thompson (1988) suggested that this effect in the N.H.L. was preceded by the emergence of the RAE in youth hockey, reporting findings of a significant relationship between birth quartile and the tier level of minor hockey league participation (X^2 of 160.89 at $p < 0.001$). The timeframe of these findings coincides with several important socio-cultural changes in Canada, which may have been contributing factors to the development of this effect (Wattie et al., 2007a).

Similar findings regarding the RAE have also been replicated in studies that examined different sports and cultures. For example, Cobley, Schorer, & Baker (2008) found the RAE among professional German soccer players and head coaches. Baxter-Jones & Helmes (1994) found the RAE among elite swimmers and tennis players. In addition, a recent meta-analysis of the RAE in sport (Cobley et al. 2009a) highlighted the effect in major league baseball (Thompson, Barnsley, & Stebelsky, 1991), soccer (Verhulst, 1992; Musch & Hay, 1999), and handball (Schorer et al., 2009). However, it is important to note that the RAE is not universal. For example, it has not been found in sports such as golf, which is typically free of annual age-groupings and selection processes in tiers of youth competition (Cobley et al., 2009a).

While the RAE has been much more extensively researched in male-dominated sports, some work does exist that has focused solely on female athletes. These studies have primarily examined adolescent age groups and have demonstrated similar findings with respect to the existence of the RAE (Cobley et al., 2009a). Edgar & O'Donoghue (2005) found a greater proportion of relatively older female tennis players at both junior and elite levels of competition. Delorme & Raspaud (2009) reported similar trends among female basketball players between 7-18 years of age. In contrast, Helsen et al. (2005) did not find the RAE in European Federation Under-18 female soccer players, nor did Vincent & Glamser (2006) report finding the effect among Olympic developmental female soccer players at state, regional, and national levels. However, a moderate RAE was found when the quartiles were collapsed into first and second halves of the year. It is important to note that only two percent of studies exploring the RAE have examined female athletes (Cobley et al., 2009a).

Specific to women's ice-hockey, Wattie & colleagues (2007a) did not find the RAE among elite female hockey players. However, this may have been the result of a small sample size. It is possible that the important socio-cultural antecedents are currently setting the stage for the emergence of the RAE in Canadian women's hockey, similar to what was seen in men's hockey in the past. Support for this idea was found by Weir et al. (2010) who reported that a higher percentage of elite female hockey players were born during the first half of the year when compared to the second (60% to 40%). This finding suggests that in agreement with previous studies, one's likelihood of success in women's elite level ice-hockey may be increased by being relatively older. However, further research is required to establish the presence of the RAE phenomenon in female ice-hockey.

RAE Mechanisms

The RAE appears to be a complex phenomenon, with no direct mechanism being identified to date. Despite the consistency of RAEs across the sport context, the mechanisms are still not completely understood. The body of current research knowledge suggests that broad socio-cultural antecedents combine with maturation-selection processes to cause participation inequalities and attainment differences among athletes of varying relative age (Cobley, Schorer, & Baker, 2008). It is likely that a combination of factors are involved, including competition, psychological development, and experience (Musch & Grondin, 2001).

Several mechanisms have been proposed to explain the RAE. The main hypotheses fit into two complementary theories (Cobley, Baker, Wattie, & McKenna, 2009a; Wattie et al., 2007a). Hockey is a sport which requires power, speed, and endurance. Therefore, Barnsley & Thompson (1988) and Barnsley et al. (1985) proposed that relatively older players were the biggest, strongest, fastest, and most coordinated individuals, and consequently experienced greater success in sports that involve physicality, such as hockey (Malina, 1994; Wattie et al., 2007a). This may be especially true during adolescence (age 12-14 in girls, age 13-15 in boys), when maturation variability is the greatest (Musch & Grondin, 2001). Secondly, relatively older athletes are more likely to be identified by coaches as talented because of their increased physical maturity and therefore selected to the more elite, representative teams where they will experience higher levels of competition, training / on-ice time, and coaching expertise (Helsen et al., 1998; Musch & Grondin, 2001). The increased access to resources provided to older players likely reinforces the RAE at subsequent levels of play, while the younger players do not have the same opportunities to develop, and may experience failure and frustration, possibly leading to withdrawal from sport involvement altogether (Delorme, Boiché, & Raspaud, 2010; Helsen et al., 1998; Barnsley & Thompson, 1988).

In the case of ice-hockey, physical capabilities are likely to be a significant factor in the RAE given that strength is of importance for body checking (Barnsley & Thompson, 1988), and also for carrying the weight of the equipment (Grondin & Trudeau, 1991). Therefore, it is reasonable to suggest that a relatively older player would possess an advantage when compared to a relatively younger player within a same-age cohort. Several studies have attributed the RAE primarily to differences in physical maturation (Baxter-Jones & Helms, 1994; Baxter-Jones, Helms, Baines-Preece, & Preece, 1994; Verhulst, 1992). This theory is especially convincing being that a one to two-year age difference can result in significant differences in the stature and weight of young children (Baxter-Jones et al., 1994; Malina, 1994), and is at its greatest variation during adolescence (Musch & Grondin, 2001). However, explanations based on physical variables alone cannot fully explain the pattern of results found in the RAE research (Musch & Grondin, 2001). For example, theories based solely on physical development predict a strong RAE at very young ages, and a reduction rather than intensification in the skewness of the distribution in subsequent years, because the differences in relative age versus total age gradually decrease rather than increase. However, there was no RAE found among the youngest players in the study conducted by Barnsley & Thompson (1988), and the magnitude of the RAE increased with increasing age, rather than decreasing in this study. Therefore, the likelihood of a complex interaction of several factors is reinforced by the research findings (Musch & Grondin, 2001).

Relative age differences in physical maturity may also be accompanied by advantages in psychological variables and life experience. Therefore, psychological theories may prove to be of importance in examining the RAE mechanism. For example, it is likely that perceived competence plays a powerful role in sport participation (Musch & Grondin, 2001). Children with higher levels of perceived competence also show a greater level of intrinsic motivation, more persistence, and exhibit higher expectations of future success (Roberts, Kleiber, & Duda, 1981; Vallerand, Deci, & Ryan, 1987). In light of the adverse effects that low self-esteem might have for relatively younger children, greater focus should be placed on the affective, cognitive, and motivational factors involved in the RAE. The importance of psychological factors is highlighted by the finding that a relative age disadvantage in education is associated with a higher rate of youth suicide (Thompson et al., 1999).

As previously mentioned, several socio-cultural antecedents may have played a role in the emergence of the RAE in the N.H.L. in the late 1970s. With regard to male ice-hockey, significant differences between birth quartiles were found for players born after 1955. This timeframe coincided with several important socio-cultural changes in Canada (Wattie et al., 2007a). For instance, Canada experienced a period of considerable population growth (Redmond, 1985) from 12 million in 1945 to 22 million in 1972 (Canada Year Book, 1952; 1972), increased popularity and interest in hockey, which was propelled by the invention and widespread availability of television (McFarlane, 1989; cf. Wattie et al., 2007a), organized youth sport grew dramatically, providing increased opportunities to play the sport (Coakley, 2004), and the increased demand for talent development to maintain Canada's dominance in hockey on the international stage (Macintosh & Whitson, 1990). The existence of the effect at the youth level prior to the professional level (Barnsley & Thompson, 1988) provides further support for the role played by the socio-cultural influences in the development of the RAE phenomenon. While Wattie and colleagues (2007a) did not find the RAE among elite female hockey players, this may have been the result of a small sample size and the socio-cultural changes needed for the RAE to emerge in Canadian women's hockey are currently at work (evidence to support this theory found in Weir et al., 2010).

Related to the concept of socio-cultural influences are studies associating population growth and the popularity of participation in a given sport with heightened competition for positions on youth sport teams, and therefore an increased likelihood of RAEs (Cobley et al., 2009). For example, a given sport's team with 20 positions available and 20 athletes interested in occupying those positions is unlikely to exhibit a RAE. However, if 200 athletes are interested in these 20 positions, then there will be strong competition to obtain a spot on the team and RAEs will be much more likely to occur. The basic principle that can be taken from this example is that "the larger the pool of potential players for a given sport in a given category, the stronger the resulting RAE should be (Musch & Grondin, pp. 154, 2001)." This concept is supported by research conducted by Grondin et al. (1984a). These researchers revealed that the RAE was stronger in highly-developed cities where there were more ice hockey players available to form teams. Another consistent finding (Grondin & Trudeau, 1991) among N.H.L. players suggested that the RAE was most evident for players born in Ontario, which has the largest population of any province in Canada. Grondin et al. (1984a) also reported a weaker RAE among volleyball players in Canada as compared to ice-hockey, which does not have the same popularity among Canadians. Although these findings do not provide direct evidence that the level of competition directly affects the magnitude of the RAE, they do suggest the possibility that competition for a position on a team increases the likelihood that a RAE will be found. Therefore, the number of players available for the number of positions, and the popularity of a given sport in a given country are likely to be important antecedents to the emergence of the RAE (Musch & Grondin, 2001).

RAE Moderators

While investigating the causes of the RAE is important, the understanding of how the effect is moderated is also of interest to researchers. Gender appears to be one of the most significant moderators of the RAE (Baker et al., 2010). As previously discussed, the majority of RAE research has focused on male athletes, and the findings of the female studies have been inconsistent. Therefore, further research attention is required. Baker et al. (2010) suggested that inconsistencies present when comparing male and female athletes may be the result of differences in competition level, sport popularity, and the age group being examined.

An athlete's age also appears to be a significant moderator of the RAE. For example, maturational differences are likely to be the greatest at the onset of puberty (Musch & Grondin, 2001). Similarly, an athlete's career stage may play a role. Cobley et al. (2009a) found that the magnitude of RAEs increase with age until late adolescence, but then decrease among adults. Likewise, Schorer et al. (2009) found similar results with German handball players. However, international players demonstrated RAEs throughout the stages of their careers. It is possible that the influence of age and career stage is related to an increased chance of injury, and / or physical or mental fatigue (Schorer et al., 2009). Therefore, relatively older players may be withdrawing from elite sport participation, leading to the decrease in RAEs among adults. However, the relationship between the RAE and moderators of this phenomenon is clearly complex and requires further investigation (Baker et al., 2010; Schorer et al., 2009).

Another potential moderator for athletes in team sports is player position. Ashworth & Heyndels (2007) reported that the RAE varied with player position in elite German soccer. Schorer & colleagues (2009) found a RAE in handball for backcourt players, where larger players have an advantage, and in the left-backcourt position, where right-handed players have an advantage and therefore there is greater competition for position due to the majority of the population being right-hand dominant. Likewise in hockey, differences in RAEs for position were reported by Grondin & Trudeau (1991), who found that the RAE was strongest for goalies, with two-thirds of them being born in the first quartile (January-March). However, Weir et al. (2010) found a RAE among forwards and defense players, but not for the goalies, although this may have been the result of a small sample size (*n* = 81). The reasons for these differences among player position are not clear, but it has been speculated that laterality may play a role; being that 90% of the population is right-handed (Raymond, Pontier, Dufour, & Moller, 1996). Increased competition is found for positions where right-handedness provides an advantage over opponents (Cobley et al., 2010; Schorer et al., 2009). Another potential consideration is that different positions require different levels of physical endurance. Therefore, the relatively older, more physically mature players may have increased physical capabilities, assisting them in meeting the physical demands of playing the position. For example, they may be more capable of carrying the weight of the equipment (Grondin & Trudeau, 1991).

Importance of RAE Research /Benefits & Consequences

The study of the RAE is important for the purpose of increasing awareness and understanding of the factors involved in this phenomenon. While it has been fairly well-established in male sport, very few studies have examined whether female athletes are facing the same issues, and what potential differences may exist between genders (Cobley et al., 2009). It is likely that the talent streaming that promotes RAEs actually reduces the talent pool, which is already smaller in female hockey. Younger players do not have the same opportunity to develop, and are more likely to have negative sport experiences, struggle with issues of competence and self-worth, and discontinue sport involvement altogether (Delorme et al., 2010; Helsen et al., 1998; Barnsley & Thompson, 1988). Helsen et al. (1998) reported that relatively younger players tended to dropout of youth soccer as early as 12 years of age. Barnsley et al. (1985) suggested that the relative age differences among young hockey players would result in varying experiences of success, leading to different participation rates based upon month of birth. This hypothesis was supported by Barnsley & Thompson (1988), who reported significantly fewer players playing with a relative age disadvantage. Likewise, Delorme & Raspaud (2009) found that relatively younger basketball players (males between ages 9 and 15 years, females between 8 and 15 years) and soccer players (males aged 8 to 17 years) were overrepresented among dropout players compared to those born closer to the cutoff date. Delorme et al. (2010) also suggested that relatively younger players may be subject to frequent situations of failure or inferiority, leading to feelings of incompetence and diminished self-worth.

While relatively older players are more likely to play on elite teams and to have professional careers as athletes (Helsen et al., 1998), it is important to note that being relatively older is not always an advantage. Wattie, Cobley, Macpherson, Howard, Montelpare, & Baker (2007b) found that relatively older players were more likely to sustain an injury in Canadian youth ice-hockey. This risk was even greater at higher levels of competitive play, possibly because of greater exposure, being that they would be playing longer, more often, and at a higher competition level. Likewise, Weir et al. (2010) observed a trend among national level female players born in the 4^{th} quartile (October-December) to have longer playing careers when compared to earlier born players, perhaps the result of greater effort and increased natural ability required to overcome the RAE. Baker & Logan (2007) found that relatively younger Canadian ice-hockey players were chosen earlier in the N.H.L. entry draft than those who were relatively older. Schorer et al. (2009) observed that the proportion of relatively younger handball players increased throughout the later career stages (greater than 30 years of age. They hypothesized that some relatively younger athletes develop superior skills, which assist them in remaining in a sport system that is unfavourable to their development.

Potential Solutions to the RAE

Solutions to the RAE should be of importance to both researchers and policy makers. Sport systems should be designed to facilitate the fullest possible development of all young athletes by making every attempt to maintain the motivation of each child. From a public health perspective, physical activity involvement is important in children and adolescents for disease prevention and promotion, with positive effects that will likely carry over into adulthood (Anderssen, 1993). Relative age disadvantages can have significant personal and social consequences if health-promoting activities are not maintained. In terms of talent development, it is likely that many promising athletes have been overlooked in the past as a result of a relative age disadvantage in early childhood (Musch & Grondin, 2001). Several suggestions to the relative age problem have been proposed in the research literature.

The earliest suggestions provided for the reduction of the RAE focused on the modification of annual age-groupings by changing the cut-off date, for example, from January to June; rotating the cut-off dates from year to year (Barnsley et al., 1985); or altering age-grouping bandwidths. However, these changes resulted in corresponding transfers of advantages, relative to who became older when the new cut-off dates were applied (Baker et al., 2010; Cobley et al., 2009a). To prevent this bias in sports, Grondin et al. (1984b) suggested an expansion of age-groupings to 15 and 21 months, as opposed to the usual 12-month groups, for the purpose of continuously rotating cut-off dates across specific ages and changing group composition. Boucher & Halliwell (1991) recommended a similar idea referred to as the "Novem System," using nine-month bandwidths to ensure that the same participants were not disadvantaged year after year. Hurley, Lior, & Traczie (2001) proposed the Relative Age Fair (RAF) Cycle System to overcome the RAE in Canadian junior ice-hockey. This system aimed to alter cut-off dates by three months for each and every consecutive hockey season to ensure that players experienced being in each of the four quartile positions, ranging from relatively oldest in the first quartile to relatively youngest in the fourth quartile. However, a smaller age bandwidth, as well as a rotating cut-off date, may prove difficult to implement due to organizational problems and the reduced number of players available for each age group if a shorter competition year applies (Baker et al., 2010; Musch & Grondin, 2001; Cobley et al., 2009a).

One alternative to chronological age divisions is a classification system based on biological age. Grouping participants according to physical characteristics such as height and weight, or a height-weight ratio, similar to the system used in wrestling and boxing, may be more sensitive to individual variability in physical characteristics; especially during the developmental stages (Cobley et al., 2009a; Musch & Grondin, 2001). A similar idea proposed by Barnsley & Thompson (1988) recommended the implementation of player quotas, where selection processes are required to meet specific birth-date distributions to prevent relatively younger players from being disadvantaged. Similarly, Helsen et al. (1998) suggested regulating the average age of the whole team, or the distribution of playing time (Baker et al., 2010). However, these strategies may prove difficult to integrate into the organizational level of sport systems, and are currently not proven to effectively resolve RAEs (Cobley et al, 2009a; Musch & Grondin, 2001).

A less challenging solution may be to simply delay the processes of selection, identification, and representation on elite teams until after the stages of puberty and maturation; for example, beyond 15-16 years of age. Selection processes facilitate earlier athlete scrutiny, assessment, and identification, which are not necessary, and increase the likelihood and magnitude of relative age inequalities. While elite sport status does require intensive long-term training and commitment, peak performance in many sports does not occur until adulthood, therefore providing a sufficient amount of time for training and development subsequent to adolescence. Delaying selection may reduce relative age disadvantages, and also indirectly help reduce the risk of compromising the health and motivation of young athletes (Cobley et al., 2009a; Baker et al., 2010).

More practical solutions may exist at the coaching level. The simple strategy of increasing awareness and understanding of the RAE, perhaps as part of coaches' training and education programs may help bring recognition to potential selection biases. Likewise, monitoring for RAEs in selection and participation may help coaches to distinguish advanced skill observed in athletes from advanced performance competency, resulting from early maturation relative to peers. Coaches should be advised to incorporate perceptual, cognitive, and motor skill criteria during athlete selection, in order to reduce the attention placed on physical characteristics (Baker et al., 2010). In addition, coaches should seek to deemphasize the focus on competition and promote each player's individual improvement in order to maintain interest, motivation, and participation in sport (Musch & Grondin, 2001).

Future RAE Research

The research findings outlined above provide justification for future multidisciplinary studies to examine the relative age effect. The data has consistently supported the presence of the RAE in several sports. However, the results have been less conclusive in other contexts. Further research in this area may provide a more accurate identification of the causes and factors involved in the RAE, or potential ways to eliminate or reduce the detrimental effects associated with it. Researchers should continue to investigate the existence and patterning of the RAE in women's sports, including the influence of player position. The reasons for the over-representation of female athletes born in the second quartile (April to June in hockey) should also be examined. In addition, the evaluation of potential solutions should include seeking ways to develop current and long-lasting participation and attainment qualities in sport (Cobley et al., 2009a; Weir et al., 2010).

Birthplace Effect / Community Size Introduction

There is also evidence to suggest that where an individual is born, and more specifically where their sport development occurs, may contribute to early sport exposure and the achievement of success in athletics (MacDonald, Cheung, Côté, & Abernethy, 2009a; Baker & Logan, 2007; Côté, MacDonald, Baker, & Abernethy, 2006). However, this theory has received limited attention in the sport expertise research when compared to the RAE (MacDonald et al., 2006; MacDonald, King, Côté, & Abernethy, 2009b). This second contextual factor has been termed the "birthplace effect." Evidence for this effect has been found in both male and female athletics, although the magnitude of the effect varies between different sports (MacDonald et al., 2009b). It is important to note that the term "community size" will be used interchangeably in this study as the location of an individual's developmental team will be used, as opposed to birthplace information (to be discussed).

As previously mentioned, a young athlete's sport development can vary as a result of different learning opportunities and the psychosocial environment in which this learning process occurs (Côté, Baker, & Abernethy, 2003). Therefore, it is reasonable to suggest that the size of the city where an athlete gains formative sport experience is a significant factor in development because it will influence how the athlete is first exposed to sports (Côté et al., 2006). For example, many children residing in smaller-sized cities have access to facilities that introduce them to sport in different ways than children from larger, urban areas. Children from larger cities may have access to a larger number of resources (for example, arenas, coaching expertise, etc.), and are also more likely to participate in sport through more structured settings (for example, leagues with coaches and scheduled practices / games). Young athletes in smaller cities are more likely to practice sport in more spontaneous, unstructured settings in comparison. There is also potential for greater diversity in player size and ability in small cities, since all the children might play together despite varying age and ability (Côté et al., 2006). In addition, children in less-populated regions may have more opportunity to play with older children and adults, and experiment with different types of sport and physical activity, which may ultimately lead to sport expertise development (Côté et al., 2003).

Previous Research Findings

Curtis & Birch (1987) were some of the first researchers to suggest the potential existence of a birthplace effect in a study of professional and Olympic male hockey players in Canada and the U.S.A. Players from smaller and middle-sized communities were significantly over-represented in professional hockey. This pattern held for communities ranging from a population of approximately 1,000 to 499,999. For example, for communities of 30,000 to 99,999 people, there was an expected proportion of 9% but actual findings revealed 19.7% in professional leagues. These findings were in sharp contrast to those for large cities of over 500,000 (expected 31.9% versus an actual representation of 20.5%) and rural communities of less than 1,000 people (expected 23.9% versus an actual representation of 6.7%). It is interesting to note that community size did not appear to be related to male youths' rate of participation in hockey in the general population.

Similar findings have also been reported by other researchers in a variety of sports. Côté et al. (2006) examined both the birthplace and birth month (for RAEs) of American National Hockey League (N.H.L.), National Basketball Association (N.B.A.), Major League Baseball (M.L.B.), and Professional Golfer's Association players, in addition to Canadian N.H.L. players. The observed findings revealed that cities with populations greater than 500,000 people were consistently under-represented among professional athletes, while communities with a population of less than 500,000 were either over-represented or of the expected proportions. A population between 50,000 and 100,000 was found to present the best chances of producing elite athletes in hockey, basketball, baseball, and golf. In addition, this study demonstrated that the birthplace effect may be considerably and consistently stronger than the well-documented RAE based on Cohen's d effect sizes (an average of 3.51 for birthplace effect and 0.44 for relative age). Overall, the results showed that the effect of birthplace and birth date were independent of each other.

Baker et al. (2009a) examined birthplace and date of birth in relation to the likelihood of becoming an Olympic athlete in Canada, the U.S.A., Germany, and the United Kingdom. Results were not exactly the same across countries. However, within-country examinations of birthplace distributions between athletes and the general population revealed several significant results. The U.S.A. analysis found a greater proportion of Olympians from cities of 30,000 to 2,500,000 people, with a significant under-representation from regions of less than 2,500 or more than five million people. Canadian data indicated that a greater likelihood of achieving Olympic status from a community larger than 100,000 people (with the exception of cities between 250,000 and 499,999 individuals) and twice as likely to become an Olympian if from a city larger than 500,000 inhabitants. Athletes from communities of less than 10,000 people were significantly under-represented. The United Kingdom analysis revealed only two significant findings. Regions between 10,000 and 29,999 were 2.34 times more likely to produce Olympic athletes, and areas between 500,000 and 999,999 were 69% less likely. Lastly, German data demonstrated that Olympic athletes were over-represented from areas with populations between 2,500,000 and 4,999,999 people and 30,000 to 249,999 people. Areas with less than 10,000 people were significantly under-represented. While this study did not reveal any RAEs, this may have been due to the wide variety of sports included in the Olympics and the different developmental system structures of these respective sports.

Specific to hockey, Baker & Logan (2007) examined the birthplace effect for American and Canadian N.H.L. draftees. American players from cities of 30,000 to 2,500,000 people were more likely to be drafted into the N.H.L., while players from regions of less than 2,500 were disadvantaged. Interestingly, players from communities with 250,000 to 999,999 inhabitants were more than 2.5 times more likely to be drafted. The odds-ratios from the Canadian data followed similar patterns, with players from cities ranging from 100,000 to 250,000 and 500,000 to 999,999 people being advantaged, and those regions of less than 10,000 people being disadvantaged. This study also reported no relationship between birthplace size and date of birth ($p = 0.90$), although both are important factors.

Carlson (1988) reported that more elite Swiss tennis players (eight of ten) were from rural areas with small clubs as opposed to urban areas with large clubs, even though they did not specialize in tennis during early adolescence. The athletes from the rural environments reported easier and unlimited access to facilities which consequently resulted in more playing time when compared to athletes from urban centers. MacDonald et al. (2009a) also reported birthplace effects in American N.F.L. players. Cities with populations below 500,000 were more likely to produce elite level football players with odds-ratios reliably higher than one. Smaller cities seemed to be particularly advantageous for producing athletic talent, specifically urban areas ranging from 50,000 to 99,999 had the highest odds-ratio (10.79). Cities over 500,000 were under-represented among N.F.L. players. However, unlike many other team sports, there were no RAEs found among football players.

Similar to RAEs, most studies have focused on male athletes. However, a study conducted by MacDonald et al. (2009b) focused on the influence of birthplace on the talent development of female American, golf and soccer athletes. They reported an over-representation of L.P.G.A. players born in cities of less than 250,000 people (an expected 45.9% versus an actual 75% of L.P.G.A. players), with cities of 50,000 to 99,999 being especially advantageous. Communities with populations greater than 250,000 were under-represented. Soccer results differed slightly in terms of advantageous population size. Cities of less than one million were significantly over-represented (an expected 69.3% versus an actual 98.6% of soccer players), and communities larger than one million were significantly under-represented. They concluded that "the birthplace effect is powerful and systematic and plays a significant role in sport expertise development regardless of the gender of the athletes (MacDonald et al., pp. 236, 2009b)."

Community Size Mechanisms

The mechanisms responsible for the birthplace effect are currently speculative (Baker & Logan, 2007). However, the weight of the research evidence suggests that it is a consistently present determinant in athletic development (MacDonald et al., 2009). It is likely that many factors play a role in its influence (Baker & Logan, 2007). Côté et al. (2006) and MacDonald et al. (2009b) suggested that the physical and psychosocial environments of large urban areas and smaller cities (excluding rural areas of less than 1000) are different, and therefore provide young athletes with difference sport experiences at early ages.

With respect to the physical environment, small to medium-sized communities may provide better opportunities to access play and experience sport-related activities, including spontaneous play. Unlike larger cities, these communities may not be as restrictive in terms of space or competitive access to sporting facilities, or as affected by residential proximity to these facilities (Baker et al., 2009; MacDonald et al., 2009b; Carlson, 1988). Small to medium-sized cities' less structured, more natural and spacious, and likely safer physical environments may promote several types of sport activities and longer hours of involvement at younger ages (Côté et al., 2006; MacDonald et al., 2009b), characteristics which have been associated with later investment in sport (Baker, Côté, & Abernethy, 2003; Soberlak & Côté, 2003). Very small, rural communities of less than 1000 people may be disadvantaged by a lack of provision (for example, coaching), facilities, and / or the number of people wanting to participate in sporting activities (Baker et al., 2009a). On the opposite side of the spectrum, athletes from very large cities may suffer from organized leagues and teams competing for use of the cities' facilities and infrastructure (Curtis & Birch, 1987; MacDonald et al., 2009a). For example, it may be that the number of indoor ice rinks and teams per capita makes a difference in youth hockey, resulting in the best players developing in communities large enough to build hockey rinks, but not so big that the demand for ice time is greater than the opportunity available to skate (Curtis & Birch, pp. 239, 1987).

From a psychosocial perspective, small to medium-sized cities may provide integrative approaches to sporting activities that promote family, school, and community involvement. As a result, young athletes may develop more supportive relationships with their coaches, while also developing a positive self-concept and the motivation necessary for long-term involvement in sport (MacDonald et al., 2009b). It is likely that the more intimate and informal environment of smaller regions is more effective at producing experiences of early success and social support for young athletes, which may promote the achievement of elite sport performance in later years (Côté et al., 2006). While larger cities may provide more options for organized sport and other structured leisure activities, urban adolescents have been reported to be less satisfied with these activities when compared to their rural counterparts (Gordon & Caltabiano, 1996). In addition, more attractive alternatives for leisure time may exist in larger cities, drawing young athletes away from hockey or other sports before elite status is achieved (Curtis & Birch, 1987). Therefore, the psychosocial environments and varying selection of extracurricular activities of small to medium-sized regions may be important determinants of future investment in sport (Côté et al., 2006).

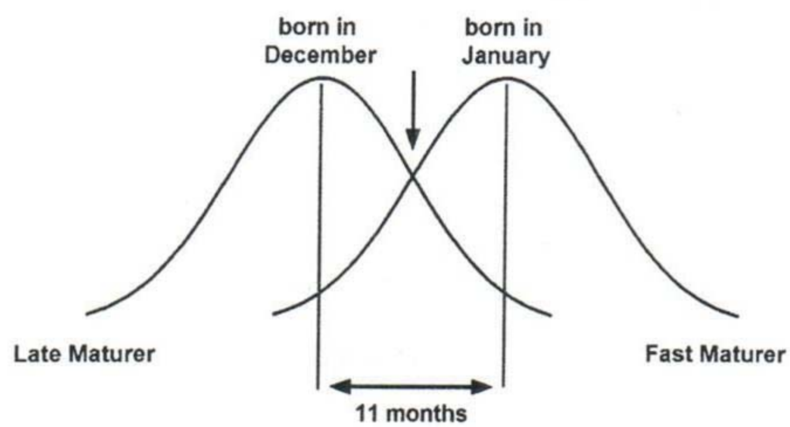
Community Size Recommendations & Future Directions

The physical and psychosocial environments of small to medium-sized cities have been found to possess the elements necessary for positive youth development, and are consistent with the eight setting features outlined by the National Research Council and

Institute of Medicine (N.R.C.I.M., 2002; MacDonald et al., 2009a). These features include: physical and psychosocial safety, appropriate structures, opportunities for skill building, supportive relationships, opportunities to belong, positive social norms, support for efficacy, and integration of family, schools, and community. Cities of all sizes should consider these aspects when developing youth sport programs. For example, youth sport should provide opportunities to experience success at young ages, and should also maintain a sense of security through developmentally and socially appropriate environments. Supportive relationships between athletes and coaches should also be reinforced to facilitate positive emotional and moral development, and ultimately enhance sport performance (MacDonald et al., 2009a). Future research in this area should seek further understanding of the mechanisms underlying the birthplace / community size effect, in addition to practical ways for larger cities and rural communities to enhance sport development and performance among their young athletes (MacDonald et al., 2009a).

Appendix B

Figure 1 – Potential Advantages / Disadvantages in Physical Maturity



This figure shows the physical maturity advantage of children born in January over those born in December of the same year. Although the child born in January has an 11-month age advantage over the child born in December, both children are group in the same age class in an age-based system with a December 31st cutoff date.

The vertical arrow in-between the distributions represents the early maturer born in December and the later maturer born in January. These two children may have the same physical age. However, the far right and far left of the distributions illustrate the potential advantage of a fast maturer born in January and a late maturer born in December.

Adapted from: Musch & Grondin, pp. 156, 2001

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